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# GROWTH OF FROST-DAMAGED DOUGLAS-FIR SEEDLINGS

by

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## ABSTRACT

*A hard frost in September 1965 severely damaged Douglas-fir seedlings at the U.S. Forest Service's Wind River Nursery near Carson, Wash. Damaged and undamaged seedlings were outplanted later the same fall and next spring. Their height growth in the next three seasons indicated that (1) some damage to Douglas-fir seedlings is hidden and cannot be identified visually months after frosting occurs; (2) even when obvious, damage may not handicap future seedling growth; (3) subsequent growth seems affected most when seedlings are lifted soon after being frosted; (4) multiple tops resulting from frost damage may be relatively unimportant. It is recommended that Douglas-fir seedlings recently damaged by frost should not be culled too heavily, else seedlings with excellent juvenile growth potential will be discarded.*

## INTRODUCTION

A hard, early frost on September 9, 1965, severely damaged many Douglas-fir seedlings growing in the Wind River Nursery near Carson, Wash. Seedlings from nearly all seed sources were affected--those from high elevations or east of the Cascade Mountains were damaged least; those from low elevations in the Cascade and Coast Ranges suffered most.

When grading freshly frosted seedlings or transplants, nurserymen usually cull heavily because they feel that the reduced needle complement may affect field survival and growth, or that injury to leaders and terminal buds might cause development of multiple tops. However, a literature

search yielded no reports on growth of seedlings outplanted soon after being frosted in the nursery and little concerning development or persistence of multiple tops following such injury.

Two studies established in 1965-66 following the frost provided data on growth potential of frosted seedlings. In one study, seedlings apparently free of frost damage were used; in the other study, growth of damaged and undamaged seedlings was compared.

## PLANTING-DATE STUDY

*Methods*

Survival and growth of 2-0 Douglas-fir seedlings planted at 6-week intervals from late October to early April were compared in a planting-date study. Seedlings from a 5,000-foot elevation source which had apparently sustained minor frost damage were planted on the Columbia Gorge District, Mount Hood National Forest. Two blocks were laid out in one clearcut; each contained five plots. On each of five dates, 10 freshly lifted seedlings were planted in each plot for a total of 100 seedlings per date. Each tree was protected from deer and rabbits by poultry netting 2 feet high, closed at the top.

*Results and Discussion*

An unexpected phenomenon occurred in the spring of 1966--terminal buds on 51 percent of the surviving trees failed to burst. Bud failures ranged from 61 percent on seedlings lifted and planted in January to 33 percent on those lifted and planted in April:

| Month planted | Live seedlings (Number) | Terminal buds failed (Percent) |
|---|---|---|
| October | 1/ 39 | 59 |
| December | 91 | 55 |
| January | 93 | 61 |
| March | 94 | 54 |
| April | 97 | 33 |

1/ Cause of excessive mortality in October was traced to dry soil at planting time.

In assessing bud failure, there is reason to wonder if a nursery condition other than frost, or a condition related to the planting site, was involved. Both nursery and planting site were snow-free during the October and December plantings, but January, March, and April plantings were made with trees lifted from under 5 feet of snow. In January, snow also had to be cleared from the planting spots. In view of frost and

snow conditions at the nursery, all seedlings were examined carefully before planting. Seedlings scraped or broken by snow shovels as well as those with buds shrivelled or needles browned by frost were rejected. Thus, bud failures occurred among seedlings that appeared undamaged when planted, and the frost was judged responsible for these failures.

The second unexpected phenomenon came to light when height growth data for three seasons were analyzed. Data for seedlings which failed to burst bud in 1966 were summed separately from data for those whose terminal buds had burst. The largest difference in average initial height of damaged and undamaged seedlings within a single planting was only 1.7 centimeters, but subsequent differences in height growth were much larger (table 1). In October, December, January, and March plantings, undamaged trees grew more than damaged trees by 7.0, 7.8, 6.5, and 3.7 centimeters, respectively. In the April planting, damaged trees grew 2.9 centimeters more than undamaged trees. Height growth in all plantings reached near-normal rate by the third season, with damaged trees of the April planting showing the largest increment.

Total height growth also varied by month of planting. Undamaged trees planted in October, December, January, March, and April grew 60.3, 49.0, 42.0, 48.8, and 57.4 centimeters, respectively; damaged trees planted in the same months grew 53.3, 41.2, 35.5, 45.1, and 60.3 centimeters, respectively.

## FROST-DAMAGE STUDY

### NURSERY PHASE

*Methods*

Fifty-six trees without frost damage were paired with 56 similar but damaged trees. Needle length, color, and apparent complement, stem diameter, and total height were the criteria used for pairing seedlings. Only those with terminals obviously withered by frost were chosen to represent damaged trees. The 2-0 seedlings, from a Siskiyou National Forest source, were lifted, paired, and replanted the same day in April 1966, about 7 months after frost damage. Trees were spaced approximately 3 feet by 3 feet apart in seven rows of 16 trees each at Wind River Nursery. Members of pairs were planted one following the other within the row to minimize effects of microsite differences. Trees were not irrigated or weeded during the study.

Total height was not recorded when trees were planted because frost-damaged trees varied in live height, and there was no indication where new leaders would arise. In fall 1967, total height and seedling height at the point of origin of the now identifiable new leader were recorded. Point of leader origin and the 1966 terminal bud scars were considered as marking the 1966 height of damaged and undamaged seedlings, respectively.

Table 1.--*Average height and accumulated growth of undamaged and damaged*[1/] *2-0 Douglas-fir seedlings planted in 5 different months*

(In centimeters)

| Year | October | | December | | January | | March | | April | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Undamaged | Damaged | Undamaged | Damaged | Undamaged | Damaged | Undamaged | Damaged | Undamaged | Damaged |
| 1965 | 29.8 | 28.1 | 29.4 | 30.4 | 26.8 | 27.3 | 26.7 | 28.1 | 24.1 | 23.3 |
| 1966 | 35.6 | 32.1 | 34.4 | 33.3 | 31.1 | 29.9 | 31.5 | 31.2 | 29.6 | 27.8 |
| 1967 | 57.5 | 50.2 | 53.8 | 48.6 | 47.5 | 43.6 | 49.3 | 47.2 | 50.2 | 47.6 |
| 1968 | 90.1 | 81.4 | 78.4 | 71.6 | 68.8 | 62.8 | 75.5 | 73.2 | 81.5 | 83.6 |
| 3-year growth | 60.3 | 53.3 | 49.0 | 41.2 | 42.0 | 35.5 | 48.8 | 45.1 | 57.4 | 60.3 |
| Growth difference | -7.0 | | -7.8 | | -6.5 | | -3.7 | | +2.9 | |

[1/] Seedlings which failed to burst bud in the first season, apparently because of hidden frost damage.

Tree heights were last measured in fall 1968. Yearly observations of damaged and undamaged trees were also made to determine relative number of seedlings with multiple tops or late flushes of growth.

*Results and Discussion*

No seedlings died during the study; and at the end of one growing season, fall 1966, undamaged trees averaged 29.4 centimeters tall compared with a 19.2-centimeter live height for damaged trees. In the 1967 and 1968 seasons, undamaged trees grew 19.9 and 37.2 centimeters, respectively, and damaged trees grew 24.5 and 46.8 centimeters (fig. 1). In 2 years, damaged trees made up their 10.2-centimeter handicap, gained an additional 4.0 centimeters, and averaged 90.5 centimeters tall; whereas undamaged trees averaged 86.5 centimeters tall. The statistical odds that this growth difference is real are better than 1,000 to 1.

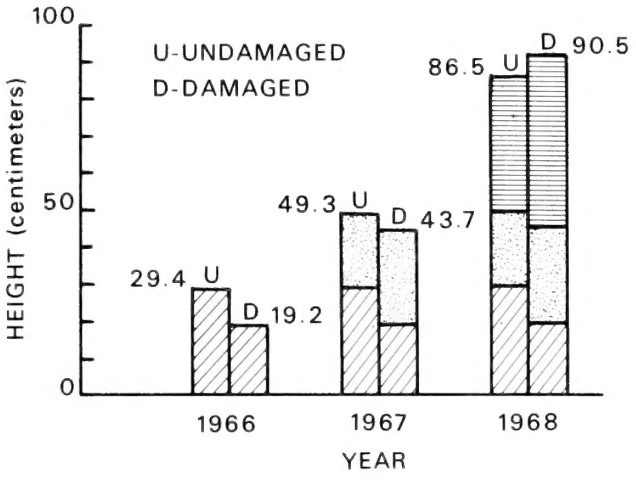


Figure 1.--*Average height at yearly intervals after planting undamaged and frost-damaged 2-0 Douglas-fir seedlings.*

Frost-damaged seedlings are prone to develop multiple tops when resuming height growth after damage. In fall 1967, 34 percent of the frost-damaged trees had multiple tops compared with 5 percent of the undamaged trees. One year later, 28 percent of the damaged trees and again 5 percent of the undamaged group had multiple tops. These figures suggest that multiple tops caused by frost damage do not persist.

In 1967, 91 percent of the damaged trees put on a second flush of growth, compared with 57 percent of the undamaged trees. Corresponding percentages for 1968 were 45 and 18, respectively. These differences suggest that trees were damaged originally because they were in a succulent state when the frost occurred; those that escaped damage had probably already set a frost-resistant bud.

## GROWTH CHAMBER PHASE

*Methods*

Growth of 15 frost-damaged seedlings rejected by graders at the nursery was compared with that of 15 frost-damaged seedlings which had been accepted. Rejected seedlings all had some live foliage but somewhat less than those that met grading standards. Seedlings were planted individually in 4-inch pots and placed randomly in a Percival environator[1/] where they were grown for 14 months under 1,400-foot-candle illumination for 16 hours per day at 85° F. and 8 hours per night at 60° F. Seedlings were then depotted. Original tops and new growth were separated, ovendried to constant weight at 158° F. (70° C.), and weighed.

*Results and Discussion*

When placed in the growth chamber, accepted seedlings had an apparent live height of 12.4 centimeters and total height of 17.5 centimeters; rejected seedlings, 8.8 and 14.3 centimeters (fig. 2). After 14 months, weight of the original top (including dead material) averaged 1.92 and 1.27 grams for accepted and rejected seedlings, respectively. These figures show that graders at the nursery tended to accept the larger damaged seedlings and reject the smaller ones.

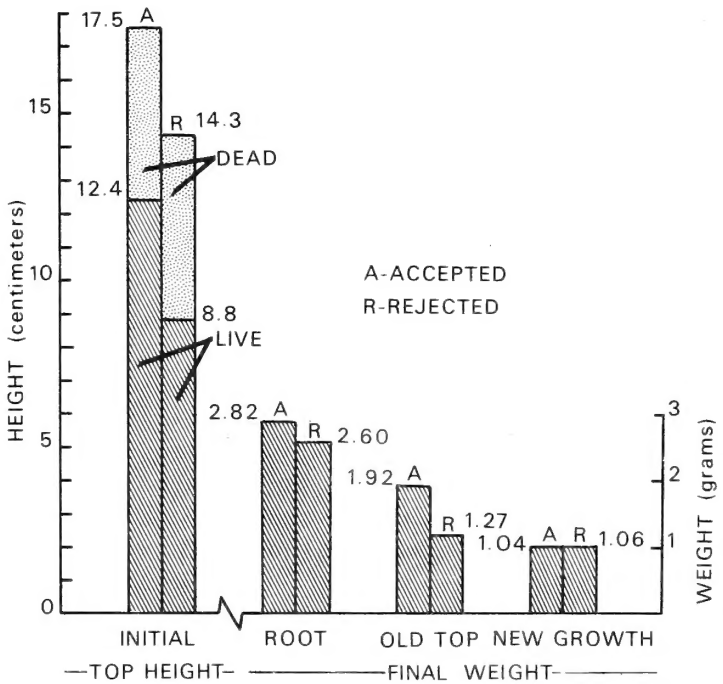


Figure 2.--*Initial height and top and root weight 14 months later of 15 accepted and rejected 2-0 Douglas-fir seedlings damaged by frost.*

[1/] Mention of products by name does not consitute an endorsement by the U.S. Department of Agriculture.

However, total weight of new top growth produced by accepted and rejected seedlings averaged 1.04 and 1.06 grams, respectively, and final weight of roots averaged 2.82 and 2.60 grams. Only one seedling, an accepted one, died. These data demonstrate that there was no difference in growth potential between the accepted and rejected groups of seedlings.

## SUMMARY AND CONCLUSIONS

Four points brought out by the two studies deserve emphasis: (1) Some damage to Douglas-fir seedlings is hidden and cannot be identified visually months after frosting occurs; (2) even when obvious, damage may not handicap future seedling growth; (3) subsequent growth seems affected most when seedlings are lifted soon after being frosted; (4) multiple tops resulting from frost damage may be relatively unimportant.

Seedlings injured by frost and lifted soon afterwards grew less in height during the first three seasons than uninjured seedlings lifted at the same time; those lifted the longest time after damage occurred grew more than uninjured seedlings lifted at the same time. This suggests that initial recovery is important and that such recovery can be facilitated by leaving the damaged seedlings in the undisturbed nursery bed as long as practical. Study data do not indicate that 2-0 seedlings moderately damaged in the fall need be held through another season in the nursery bed, however.

The tendency for more damaged than undamaged trees to double-flush suggests that they were faster growing prior to being damaged. In fact, their tendency to double-flush is probably the reason they were damaged--their tops may still have been succulent when frost occurred whereas tops of those having a single flush of growth probably were partially or fully hardened off.

Development of multiple tops on frost-damaged Douglas-fir seedlings may be only a trivial matter. Other damaging agents also cause multiple tops--for instance, animal browsing. Our observations and those of others suggest that a single top may assume dominance on damaged trees in a short time. The rarity of older Douglas-fir trees with forks near the ground provides further evidence that multiple leaders on seedlings of this species are of fleeting importance.

Nurserymen and field foresters have no proven criteria for grading frost-damaged seedlings. Since many terminal buds are killed by frost yet show no visible evidence of damage, graders cannot cull all frosted trees even if they think they should. Furthermore, these studies demonstrate that many frost-damaged seedlings should not be culled. Frost-damaged seedlings appear to have been the fastest growing ones before they were damaged and to remain so after damage. If this is so, it would

be a mistake to discriminate against all frost-damaged trees in nursery grading. Not only would we be throwing away trees with good juvenile growth potential in an era when rapid growth is receiving increased emphasis, but we might also be removing desirable growth traits from the next generation of trees.

How much height or needle complement frosted seedlings can lose and still fully recover remains an unanswered question. Until more definitive work can be done on frost damage, the message is: Don't cull frost-damaged Douglas-fir seedlings too heavily; some of them may be our fastest growing stock.